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DEPARTMENT OF THE INTERIOR
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JOSEPH A. HOLMES, DIRECTOR

IGNITION OF GAS

BY

STANDARD INCANDESCENT LAMPS

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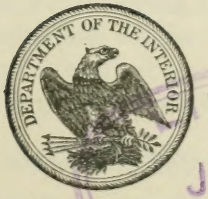
ENGINEERING
ENGIN STORAGE

BY

H. H. CLARK



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IGNITION OF GAS BY STANDARD INCANDESCENT LAMPS.

By H. H. Clark.

INTRODUCTION.

Electric incandescent lamps are used in a large number of mines. Almost all mines in which electric current is available use electricity to some extent for underground lighting. The design and construction of incandescent lamps is such that, when properly installed, they offer ordinarily only a small fire hazard, because the filaments are so quickly broken to pieces when the bulbs are fractured that there is not time to raise to its ignition point material that is merely combustible. The presence of explosive mixtures of gases, however, increases the risk. When an incandescent lamp bulb is broken in an explosive mixture of gas this mixture is brought into violent contact with a wire having a temperature of 1,800 to 2,000° C., or two to three times the ignition temperature of methane.

The potential danger represented by the use of electric lamps in mines where gas is likely to be present is recognized in some foreign countries by their mining laws,[a] and in the United States by the American Mining Congress[b] and the State of Pennsylvania.[c]

The Bureau of Mines has made a study of the action of incandescent lamps when, under various conditions and in different ways, the bulbs are opened in gaseous atmospheres. The investigation has been carried out in a practical rather than a theoretical way, although certain pertinent theoretical points will be discussed in a forthcoming bulletin describing the investigations in detail. This paper summarizes the results of the tests, and is issued as a preliminary statement.

LAMPS TESTED.

Twelve hundred and nineteen incandescent lamps, representing the product of eight manufacturers, were used in the investigation. The lamps were similar to those used for general lighting purposes wherever electric incandescent systems are operated.

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a Great Britain: Special rules relating to the installation of electricity in mines. Rule 15, Sec. 4. Coal mines regulation act, 1902. Rule 67.

b Report of committee on standardization of electric equipment in coal mines. Sec. 7, par. 83. Am. Min. Congress.

c Bituminous mine law. Commonwealth of Pennsylvania, 1911. Sec. 7, par. 83.

The table following gives the approximate rating of each size of lamp tested and shows how many lamps of each size were used.

TABLE 1.—*Number and rating of lamps tested.*

Number used.	Approximate candle-power.	Rated wattage.	Rated voltage.	Character of filament.
30	8	28	50	Carbon.
101	8	25 30	55	Do.
10	16	55	50	Do.
92	16	50 60	55	Do.
64	32	100 120	55	Do.
25	50	155 175	55	Do.
125	8	25 30	110	Do.
160	16	50 60	110	Do.
92	32	100 120	110	Do.
8	32	110	127	Do.
30	50	155 175	110	Do.
115	8	28 35	220	Do.
131	16	55 60	220	Do.
149	32	110 120	220	Do.
56	50	175 190	220–225	Do.
11	20	25	110	Tungsten.
20	20	25	220	Do.
1,219				

CHARACTER OF TESTS.

The general method of testing the lamps was to cause an explosive mixture of gas[a] and air to come in contact with the filaments while they were glowing at normal or more than normal brilliancy. Such contact was brought about either by smashing a bulb with a sudden blow, by snipping off the tip, or by puncturing a hole in the neck. A few tests were made by removing the glass, surrounding the filament with gas, and then impressing rated potential upon the filament.

The table following gives in condensed form the conditions of each test:

TABLE 2.—*Conditions of test.*

Test No.	Voltage applied to lamps.	Bulbs broken by—	Percentage of gas.
1	Rated	Smashing	8.6
2	More than rated	do	8.6
3	Rated	do	(a)
4	do	Snipping tip	8.6
5	do	Puncturing	8.6
6	do	(b)	8.6

a Greater and less than 8.6.

b In test No. 6 the glass bulb was removed and rated voltage was applied to the filament after surrounding it with gas.

RESULTS OF THE INVESTIGATION.

The results of the tests are given below in tabular form. This table shows the number of tests of each kind made on each size of lamp and the percentage of ignitions that took place.

a Natural gas from the Pittsburgh city mains was used in these mixtures. It contains about 82 per cent methane, 16.4 per cent ethane, 1.5 per cent nitrogen, and a trace of carbon dioxide. The most explosive mixture of this natural gas and air contains 8.6 per cent gas.

TABLE 3.—*Number of tests and percentage of ignitions.*

Rating of lamp.	Smash test; rated voltage.[a]		Smash test; overenergized lamp.[b]		Smash test; percentage of gas varied from 8.6 per cent.[c]		Tip-breaking test.[d]		Puncture test.[e]		Naked filament test.[f]	
	Number of tests.	Percentage of ignitions.	Number of tests.	Percentage of ignitions.	Number of tests.	Percentage of ignitions.	Number of tests.	Percentage of ignitions.	Number of tests.	Percentage of ignitions.	Number of tests.	Percentage of ignitions.
8 candlepower, 50 volts	4	0	6	33	....	....	5	0	....	....	....	....
8 candlepower, 55 volts	5	0	3	0	....	....	5	40	4	100	4	100
30 watts, 50 volts	4	0	6	66.7	....	....	5	40	....	....	....	....
30 watts, 55 volts	24	8.3	36	58.3	....	....	10	30	10	80	....	....
16 candlepower, 55 volts	16	18.7	....	....	....	....	3	0	2	100	4	100
50 watts, 55 volts	4	25	....	....	....	....	....	....	....	....	....	....
60 watts, 50 volts	10	80	....	....	....	....	....	....	....	....	....	....
60 watts, 55 volts	20	95	....	....	28	60.7	15	60	....	....	....	....
32 candlepower, 55 volts	5	100	....	....	1	100	8	75	5	60	4	100
100 watts, 55 volts	2	100	....	....	....	....	....	....	....	....	....	....
120 watts, 55 volts	10	100	....	....	24	75	5	60	....	....	....	....
50 candlepower, 55 volts	7	100	....	....	....	....	....	....	....	....	....	....
155 to 175 watts, 55 volts	8	100	....	....	....	....	10	80	....	....	....	....
8 candlepower, 110 volts	8	12.5	18	50	....	....	7	0	3	100	3	100
25 watts, 110 volts	2	0	6	33.3	....	....	....	....	....	....	....	....
30 watts, 110 volts	12	0	36	44.4	....	....	15	13.3	15	46.7	....	....
16 candlepower, 110 volts	8	0	19	52.6	3	0	8	12.5	3	100	4	100
50 watts, 110 volts	12	8.3	3	66.7	....	....	....	....	....	....	....	....
60 watts, 110 volts	32	9.4	36	41.7	7	14.3	15	13.3	10	60	....	....
32 candlepower, 110 volts	6	50	....	....	....	....	2	0	2	100	3	100
32 candlepower, 127 volts	8	62.5	....	....	....	....	....	....	....	....	....	....
100 watts, 110 volts	4	75	....	....	....	....	5	60	....	....	....	....
120 watts, 110 volts	48	50	2	50	5	80	15	33.3	....	....	....	....
50 candlepower, 110 volts	7	85.7	....	....	....	....	5	100	....	....	....	....
155 watts, 110 volts	4	100	....	....	....	....	5	40	....	....	....	....
175 watts, 110 volts	4	100	....	....	....	....	5	20	....	....	....	....
8 candlepower, 220 volts	3	0	8	25	....	....	5	20	2	100	3	100
35 watts, 220 volts	14	0	42	21.4	....	....	20	5	18	44.4	....	....
16 candlepower, 220 volts	5	0	12	41.7	....	....	11	0	5	40	4	100
60 watts, 220 volts	22	4.5	42	57.1	....	....	15	13.3	15	66.7	....	....
32 candlepower, 220 volts	7	0	16	56.3	....	....	3	33.3	3	66.7	4	100
120 watts, 220 volts	44	2.3	42	50	....	....	20	20	10	80	....	....
50 candlepower, 220 to 225 volts	20	80	....	....	....	....	6	66.7	2	100	2	100
190 watts, 220 volts	16	68.7	....	....	....	....	10	50	....	....	....	....
20 watts, 110 volts [g]	7	85.7	....	....	....	....	4	75	....	....	....	....
20 watts, 220 volts [g]	14	28.6	....	....	....	....	6	0	....	....	....	....
Total	426	.....	333	.....	68	.....	248	.....	109	.....	35	....

[a] Test No. 1. See Table 2.
[b] Test No. 2. See Table 2.
[c] Test No. 3. See Table 2.
[d] Test No. 4. See Table 2.
[e] Test No. 5. See Table 2.
[f] Test No. 6. See Table 2.
[g] The last two items are tungsten-filament lamps; all others are carbon-filament lamps.

PUBLICATIONS ON MINE ACCIDENTS AND TESTS OF EXPLOSIVES.

The following Bureau of Mines publications may be obtained free by applying to the Director, Bureau of Mines, Washington, D. C.

BULLETIN 10. The use of permissible explosives, by J. J. Rutledge and Clarence Hall. 1912. 34 pp., 5 pls.

BULLETIN 15. Investigations of explosives used in coal mines, by Clarence Hall, W. O. Snelling, and S. P. Howell, with a chapter on the natural gas used at Pittsburgh, by G. A. Burrell, and an introduction by C. E. Munroe. 1911. 197 pp., 7 pls.

BULLETIN 17. A primer on explosives for coal miners, by C. E. Munroe and Clarence Hall. 61 pp., 10 pls. Reprint of United States Geological Survey Bulletin 423.

BULLETIN 20. The explosibility of coal dust, by G. S. Rice, with chapters by J. C. W. Frazer, Axel Larsen, Frank Haas, and Carl Scholz. 204 pp., 14 pls. Reprint of United States Geological Survey Bulletin 425.

BULLETIN 26. Notes on explosive mine gases and dusts, by R. T. Chamberlin. 67 pp. Reprint of United States Geological Survey Bulletin 383.

BULLETIN 44. First national mine-safety demonstration, by H. M. Wilson and A. H. Fay, with a chapter on the explosion at the experimental mine, by G. S. Rice. 1912. 75 pp., 7 pls.

TECHNICAL PAPER 4. The electrical section of the Bureau of Mines, its purpose and equipment, by H. H. Clark. 1911. 12 pp.

TECHNICAL PAPER 6. The rate of burning of fuse as influenced by temperature and pressure, by W. O. Snelling and W. C. Cope. 1912. 28 pp.

TECHNICAL PAPER 7. Investigations of fuse and miners' squibs, by Clarence Hall and S. P. Howell. 1912. 19 pp.

TECHNICAL PAPER 11. The use of mice and birds for detecting carbon monoxide after mine fires and explosions, by G. A. Burrell. 1912. 15 pp.

TECHNICAL PAPER 12. The behavior of nitroglycerin when heated, by W. O. Snelling and C. G. Storm. 1912. 14 pp., 1 pl.

TECHNICAL PAPER 13. Gas analysis as an aid in fighting mine fires, by G. A. Burrell and F. M. Seibert. 1912. 16 pp.

TECHNICAL PAPER 17. The effect of stemming on the efficiency of explosives, by W. O. Snelling and Clarence Hall. 1912. 20 pp.

TECHNICAL PAPER 18. Magazines and thaw houses for explosives, by Clarence Hall and S. P. Howell. 1912. 34 pp., 1 pl.

TECHNICAL PAPER 19. The factor of safety in mine electrical installations, by H. H. Clark. 1912. 14 pp.

TECHNICAL PAPER 21. The prevention of mine explosions; report and recommendations, by Victor Watteyne, Carl Meissner, and Arthur Desborough. 12 pp. Reprint of United States Geological Survey Bulletin 369.

MINERS' CIRCULAR 2. Permissible explosives tested prior to January 1, 1911, and precautions to be taken in their use, by Clarence Hall. 1911. 12 pp.

MINERS' CIRCULAR 3. Coal-dust explosions, by G. S. Rice. 1911. 22 pp.

MINERS' CIRCULAR 4. The use and care of mine-rescue breathing apparatus, by J. W. Paul. 1911. 24 pp.

MINERS' CIRCULAR 5. Electrical accidents in mines; their causes and prevention, by H. H. Clark, W. D. Roberts, L. C. Ilsley, and H. F. Randolph. 1911. 10 pp., 3 pls.

MINERS' CIRCULAR 6. Permissible explosives tested prior to January 1, 1912, and precautions to be taken in their use, by Clarence Hall. 1912. 20 pp.

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